

COOLANT DELIVERY APPARTUS FOR MACHINE TOOL

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This application claims the benefit of U.S. Provisional Patent Application No. 60/459,122 filed March 31, 2003.

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Field of the Invention

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[0001] The present invention is directed to machine tools and in particular to an apparatus for delivering coolant to a tool and workpiece during machining, especially during grinding of cutting blades.

Background of the Invention

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[0002] It is well known to manufacture gears, such as bevel and hypoid gears, with stick-type cutting blades made from, for example, high speed steel or carbide materials. It is further known that to form, or to restore, the desired surfaces and edges on stick-type cutting blades, grinding operations must be performed on the cutting blades. Examples of such cutting blades can be found in U.S. Patents Nos. 4,575,285 to Blakesley; 5,890,846 to Clark et al. or 6,120,217 to Stadtfeld et al. Cutting blades of this type have cutting and clearance profile surfaces as well as a top surface that are ground during sharpening. Other cutting blades are known where in addition to grinding the cutting, clearance and top surfaces as described above, the front face of the cutting blade is also ground when sharpening.

[0003] Cutting blade grinding machines (which also may be referred to as “sharpening” machines) for grinding cutting blades include some type of clamping mechanism for holding one or more cutting blades in position during grinding. Such clamping mechanisms generally hold a cutting blade in an angled orientation with respect to the axis of the clamping mechanism, or, in a “zero angle” orientation wherein the cutting blade is positioned coincident or parallel with the axis of the clamping mechanism.

[0004] In grinding a cutting blade in an angled orientation, the area of contact between the cutting blade and the grinding wheel generally stays in about the same location on the grinding wheel because the clamping mechanism remains in the same position (or 180 degrees relative to that position) during grinding. Such positioning keeps the top surface of the cutting blade positioned relative to the grinding wheel at about the same area of the grinding wheel during the grinding process. Thus, when introducing coolant during the grinding process, one or more coolant nozzles can be positioned and allowed to remain in the same position as the cutting blade is ground. However, with clamping mechanisms of the angled type, the orientation of a cutting blade is dependent upon the top angle of the cutting blade as well as the mounting angle of the cutting blade in its intended cutter head. Therefore, grinding cutting blades with different top or mounting angles requires different clamping mechanisms or positioning inserts in the clamping mechanism to accommodate the different cutting blades.

[0005] With clamping mechanisms of the “zero angle” type, the orientation of each blade remains parallel with the axis of the clamping mechanism during grinding. However, if it becomes necessary to rotate the clamping mechanism to different positions during grinding in order to properly grind the different surfaces on the cutting blade, the location of the contact area on the grinding wheel change may change. Thus, it becomes necessary to either reorient the positions of coolant nozzles or provide a plurality of coolant nozzles positioned to account for the different locations of the grinding area

on the grinding wheel. Usually, coolant lines extend from a coolant header mounted stationary on the grinding wheel side of the machine. Having many coolant lines, and hence many coolant nozzles, can result on interference situations with machine components as well as requiring a greater volume of coolant as the number of lines increases.

Summary of the Invention

[0006] The present invention is directed to a coolant delivery apparatus for a machine tool wherein the position of the coolant delivery apparatus is controllable such that coolant may be delivered to the machining zone of a tool even though the location of the machining zone of the tool may change such as during machining of a workpiece, or from one workpiece to another.

Brief Description of the Drawings

[0007] Figure 1 illustrates a type of cutting blade grinding machine on which the inventive coolant delivery apparatus may be included.

[0008] Figure 2 shows an example of a "zero angle" cutting blade clamping mechanism.

[0009] Figures 3(a) and 3(b) illustrate grinding zones of a grinding wheel with a cutting blade positioned in an "angled" clamping mechanism.

[0010] Figures 4(a) and 4(b) illustrate grinding zones of a grinding wheel with a cutting blade positioned in a "zero angle" clamping mechanism.

[0011] Figure 5 illustrates an elevated view of a preferred embodiment of the inventive coolant delivery apparatus.

5 [0012] Figure 6 illustrates a cross-sectional view of the embodiment of the inventive coolant delivery apparatus of Figure 5.

[0013] Figure 7 shows the inventive embodiment of Figure 5 in position on a cutting blade grinding machine.

10 [0014] Figure 8 illustrates a preferred type of mechanism for controlling the rotational position of the inventive coolant delivery apparatus.

Detailed Description of the Preferred Embodiment

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[0015] In the drawings, which illustrate the present invention by way of example only, like components will be identified with the same reference number.

20 [0016] Figure 1 illustrates one type of cutting blade grinding machine 2. The machine is shown only with those elements necessary to gain a general understanding of the machine since the machine, per se, is not part of the present invention. Machines of this type are commercially available, for example, from The Gleason Works, Rochester, New York.

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[0017] In Figure 1, grinding machine 2 includes a workpiece clamping mechanism 4 rotatable in a direction C about the axis of the clamping mechanism and a grinding wheel 6 rotatable in a direction S about the axis of the grinding wheel. The grinding wheel is movable relative to the clamping mechanism in three linear directions X, Y and Z (preferably mutually perpendicular) and is angularly positionable in a direction A. The grinding

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machine includes a dressing mechanism 10, rotatable in a direction D, for periodic restoration of the surface of the grinding wheel 8.

[0018] Figure 2 illustrates a known type of "zero angle" clamping mechanism 4 in which is secured a stick-type cutting blade 22. Clamping mechanism 4 comprises an outer ring portion 4 having at least one clamp 14 attached to clamp bracket 16. Clamp 14 engages cutting blade 22 to clamp it in position against mounting surfaces 24 and 26 which together define a mounting slot of mounting block 28. The clamping mechanism is rotationally positionable so that a cutting blade can be brought to different positions such that, if process parameters dictate, all appropriate surfaces can be ground.

[0019] When cutting blades are sharpened, it is important to direct coolant such that the cutting blade as well as the grinding wheel are adequately cooled and lubricated and, the material removed from the cutting blades is efficiently washed away from the cutting blade and grinding wheel. Proper placement of coolant nozzles is, therefore, essential so that the above objectives are accomplished.

[0020] As mentioned above, for angled clamping mechanisms, such as shown in Figures 3(a) and 3(b), rotating the clamping mechanism 30 by 180 degrees in order to grind the cutting and clearance side surfaces of a stick-type cutting blade 32 brings the top of the cutting blade to about the same area or zone, Z_1 , of the grinding wheel 34. This is due to the cutting blade 32 being mounted in the clamping mechanism 30 at an angle α based on the top angle of the cutting blade and the angle of inclination of the cutting blade in its intended cutter head. Providing coolant to the grinding wheel and cutting blade is a matter of orienting a desired number of coolant nozzles to provide coolant to the zone Z_1 which does not change significantly when the cutting blade is repositioned to grind the other side surface.

[0021] In Figures 4(a) and 4(b) a “zero angle” clamping mechanism 40 is shown. With this type of clamping, and under certain process conditions such as utilizing dedicated edges of the grinding wheel for roughing and finishing operations such as described in commonly assigned U.S. Patent Application Publication No. 2003/0148717, the disclosure of which is hereby incorporated by reference, rotation of the clamping mechanism to position the cutting blade 32 for grinding the cutting and clearance sides is accompanied by relative movement of the grinding wheel 34 and cutting blade 32 to reposition the grinding wheel appropriately for grinding the respective side surface. For example, in Figure 4(a), one side of cutting blade 32 is ground at zone Z_2 of grinding wheel 34 while in order to grind the other side of cutting blade 32 with the same edge of the grinding wheel, clamping mechanism 30 is rotated to reposition cutting blade 32 and grinding now occurs at zone Z_3 of grinding wheel 34 (Figure 4(b)). Additionally, other surfaces of the cutting blade 32 may require repositioning the clamping mechanism again, such as grinding the front face, thereby resulting in another zone of the grinding wheel being utilized, for example, zone Z_4 in Figure 4(b).

[0022] In moving the grinding wheel 34 from zone Z_2 to zone Z_3 , relative movement between the grinding wheel and cutting blade must occur. If the page of Figures 4(a) and 4(b) is considered to represent the X-Z plane of the machine of Figure 1, it can be seen that movement to different zones on grinding wheel 34 involves relative movement between the cutting blade and grinding wheel at least in the X direction. It can be seen that coolant nozzles positioned about the grinding wheel at zone Z_2 will be sufficient as long as grinding takes place at zone Z_2 . However, upon shifting of the grinding to another zone, such as Z_3 and/or Z_4 for example, optimum coolant flow will still be directed to zone Z_2 .

[0023] The inventor has developed a coolant delivery assembly to address the drawback discussed above. Figures 5 and 6 show the inventive coolant assembly 40 comprising a generally ring-shaped configuration having a

mounting adapter 42, a coolant header 44 and a retaining cap 46. The coolant assembly is preferably positioned attached to the end of the spindle housing 48 (Figures 1 or 7) of the grinding wheel spindle 49 via the mounting adapter 42 by a plurality of screws 50 (four are shown). The coolant header 44 is positionable and rotatable about mounting adapter 42. Retaining cap 46 is attached to mounting adapter 42 by a plurality of screws 52 (one shown in Figure 6) to keep the coolant header 44 in position. Coolant header 44 is also rotatable about retaining cap 46.

[0024] With the coolant assembly positioned attached to the spindle housing 48 as shown in Figure 7, one or more, preferably four, coolant nozzles 54 which extend from the coolant header 44 are positioned adjacent to the grinding wheel 8. Coolant is supplied to the coolant header 44 via a feed pipe 56. Alternatively, coolant may be supplied through spindle housing 48 to appropriate channels extending through mounting adapter 42 and communicating with coolant header 44.

[0025] Changing the grinding zone position on the grinding wheel is accomplished by X direction movement in the machine of Figure 1. The present invention provides means to rotate the coolant header 44 in a synchronized manner with movement of the grinding wheel in the X direction so that the position of the coolant nozzles moves to remain adjacent to the grinding zone being utilized. Rotation of the coolant header 44 is preferably effected by a cable system comprising a pair of cables 58, 60 (Figure 5) each attached to a respective end 64, 66 of a semi-circular plate 62 attached to the coolant header 44. The periphery of plate 62 is grooved to accommodate the cables 58, 60 with each cable having a ball at its end which fits into a similarly shaped receptacle located at each plate end 64, 66. The cables extend from the plate ends 64, 66, along the groove in the plate periphery, over the respective pulley 68, 70 enclosed in housing 72, and extend to a bracket 74 mounted to the X direction slide 76 of the grinding machine. Another bracket 78 is mounted to a stationary surface adjacent slide 76 and the sheaths of the

cables 58, 60 are attached to the bracket 78 so as to hold them stationary and permit movement of the cables within.

5 **[0026]** With the above arrangement, movement of the slide 76 in the X direction will pull a respective cable 58 or 60 causing movement of plate 62 and, hence, rotation of coolant header 44 and nozzles 54. Thus, for example, if movement of the grinding zone in Figures 4(a) and (b) from Z_2 to Z_3 requires a 1 inch (25.4 mm) movement of X direction slide 76, cable 58 will be pulled by this amount and coolant header 44 and nozzles 58 will likewise rotate by
10 this amount to shift the position of the coolant nozzles from zone Z_2 to zone Z_3 about the grinding wheel. The same principle applies to movement between any grinding zones on the grinding wheel.

15 **[0027]** While a cable system has been illustrated and is preferred, other systems that synchronize movement in the X-direction to repositioning of the coolant nozzles 58 are also contemplated. For example, a system utilizing servomotors may be utilized. Also, although the system shown employs a 1:1 ratio of X-direction movement to nozzle rotation distance, other ratios are within the scope of the present invention.

20 **[0028]** It is further noted that although the present invention has been discussed with the respect to a grinding machine having the configuration as shown in Figure 1, the invention is not limited thereto. The present invention applies to any grinding machine where moving from one grinding zone to
25 another involves a component of motion in the plane of the grinding wheel where the component is perpendicular to the direction of the axis of the clamping mechanism. In other words, the present invention may be applied to any grinding machine having directions of motion corresponding to X and Z of Figure 1.

30 **[0029]** While the invention has been described with reference to preferred embodiments it is to be understood that the invention is not limited to the

particulars thereof. The present invention is intended to include modifications which would be apparent to those skilled in the art to which the subject matter pertains without deviating from the spirit and scope of the appended claims.